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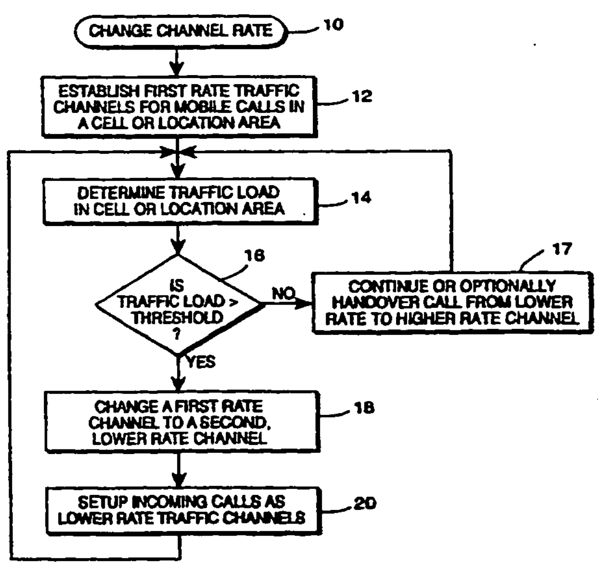
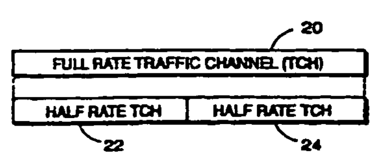
(54) Title: INCREASING TRAFFIC CAPACITY IN A CELLULAR COMMUNICATIONS SYSTEM BY CHANGE OF TRAFFIC CHANNEL RATE

(57) Abstract

The present invention dynamically increases the capacity of a cellular radio communications system to meet temporary high traffic demands effectively and economically. The current traffic load at a particular base station cell area is determined (14). If the determined traffic load exceeds a threshold (16), a higher rate traffic channel over which a dual rate mobile station is communicating is handed over to a lower rate traffic channel available in that cell area (18). A list is maintained for those dual rate mobile stations currently assigned to higher rate traffic channels. Before making the handover from the higher rate traffic channel to the lower rate traffic channel, it is determined whether a handover is permitted. If so, the intra-cell handover is preferably made to a traffic channel which is currently already supporting another lower rate call. Otherwise, any available lower rate traffic channel is assigned. At call setup, if the current traffic load in the cell area exceeds the threshold, a call request involving a dual rate mobile station is assigned a lower rate traffic channel (20). If the traffic load in the cell area decreases, a call intitially set up or subsequently handed over to a lower rate channel because of high traffic load may optionally be handed over to a higher rate channel (17).





INCREASING TRAFFIC CAPACITY IN A CELLULAR COMMUNICATIONS SYSTEM BY CHANGE OF TRAFFIC CHANNEL RATE

FIELD OF THE INVENTION

The present invention relates to increasing traffic capacity in a cellular radio communications system, and more particularly, to increasing traffic capacity by changing a requested or initially selected traffic channel rate to a lower bit rate when extra traffic capacity is needed.

BACKGROUND AND SUMMARY OF THE INVENTION

In the Global System for Mobile communications (GSM), two bit rates for speech coders are defined: full rate and half rate. Full rate corresponds to a bit rate of 13 kbits/s, and half rate corresponds to a bit rate of 6.5 kbits/s. A traffic channel in the GSM system can support one full rate speech call or two half rate speech calls. Speech coding significantly lowers the bit rate over the radio interface (higher bit rates take up too much of the frequency spectrum) while still providing acceptable speech quality. In general, speech coding sends information about the speech (rather than the speech itself) from which the speech signal can be reconstructed at the receiver.

The GSM also employs time division multiple access (TDMA) with each radio frequency carrier being divided into eight time slots (TS). One time slot in a TDMA frame is called a physical channel, and each duplex pair of frequency carriers includes eight physical channels. Speech and other information are sent on logical traffic channels (TCH) mapped onto the physical time slot channels. In full rate traffic channels, a user is assigned a single physical channel/time slot. For half rate traffic channels, two mobile stations share the same physical channel/time slot with each mobile station alternating use of the allocated time slot.

channels may be used in favorable traffic conditions but half rate channels are employed during temporary high traffic conditions.

The present invention increases the capacity in a cellular radio communications system in accordance with the following method. Initially, a higher rate traffic channel is established for communication with a mobile station located in a particular cell area. The current traffic load at that cell area is determined. If the determined traffic load exceeds a threshold, the higher rate traffic channel over which a dual rate mobile station is communicating is handed over to another lower rate traffic channel available in that cell area. For currently active traffic channels, a list is maintained for those dual rate mobile stations currently assigned to higher rate traffic channels.

Before making the handover from the higher rate traffic channel to the lower rate traffic channel, it is determined whether such a handover is permitted. If so, the intra-cell handover is preferably made to a traffic channel which is currently already supporting another lower rate call. Otherwise, any available lower rate traffic channel is assigned.

At call setup, if the current traffic load in the cell area exceeds the threshold, a call request involving a dual rate mobile is assigned a lower rate traffic channel. If the traffic load in the cell area decreases, a call initially setup or subsequently handed over to a lower rate channel because of high traffic load may be handed over to a higher rate channel.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts

descriptions of well-known methods, interfaces, devices, and signaling techniques are omitted so as not to obscure the description of the present invention with unnecessary detail.

Because the application is applicable to any cellular telephone communications systems, a first example embodiment of the present invention is now described in general terms. The flowchart in Fig. 1 outlines the steps of a Change Channel Rate routine (block 10). Assuming a light or moderate traffic load initially, traffic channels are established for mobile calls in a particular cell, sector, or other location area at a first traffic rate (block 12) in accordance with normal channel request and assignment procedures. The traffic load in the cell or location area is determined (block 14). A decision is made in block 16 whether the traffic load for that cell or location area exceeds a threshold, i.e., whether there has been temporary increase in traffic demand. If not, the mobile communications continue as set up (block 17). However, if the traffic load exceeds a threshold, a dual rate mobile communication being conducted over a traffic channel at a first rate is handed over to another traffic channel where the communication is conducted a second lower rate (block 18). Moreover, new incoming calls for dual rate mobiles are set up as lower rate calls rather than higher rate calls until the traffic load decreases below the threshold. If the traffic load decreases significantly, calls may optionally be handed over from lower rate traffic channels to available higher rate traffic channels (block 17).

Thus, the present invention provides a temporary increase of the traffic capacity of a cell by utilizing lower rate capabilities of some dual rate mobile stations operating in the cell. Because the communication connections are moved within the serving cell, i.e., intra-cell handoffs, there is no increase in interference level that might be experienced if inter-cell handoffs to other cells were employed. Another advantage of the present invention is that no additional hardware is required. Reserve but often underutilized base station transceivers are not needed to ensure sufficient capacity for

The gateway MSC 36 is the interface point in the mobile radio network for calls to mobile subscribers. Although the GMSC 36 is shown as a separate node for clarity of illustration, it may be located with an MSC 38. Each mobile switching center 38 performs telephony switching functions associated with calls involving a mobile station (MS) 46 including interfacing with other telecommunications networks 32 and 34 and routing mobile-originated calls.

Each MSC 38 is associated with a Visiting Location Register (VLR) 40 which includes a database containing temporary subscriber information needed by its associated MSC 38 to provide services to mobile stations in the MSC's service area. Typically, when a mobile station enters a visiting network or service area, it registers with the VLR 40 which then requests and receives data about the roaming mobile station from the mobile's Home Location Register (HLR) 41 and stores it. As a result, when the visiting mobile station is involved in a call, the VLR 40 already has the information needed for call setup. While the VLR 40 may be a stand-alone node, it is preferably integrated with its associated MSC to eliminate signaling between the two nodes.

The home location register (HLR) 41 is a database node that stores and manages subscriptions. For each "home" mobile subscriber, the HLR 41 contains permanent subscriber data such as the Mobile Station ISDN Number (MSISDN) which uniquely identifies the mobile telephone subscription in a PSTN numbering plan, and an international mobile subscriber identity (IMSI), which is a unique identity allocated to each mobile subscriber and used for signaling for in the mobile network. All network-related subscriber information is connected to the IMSI. The HLR 41 contains a list of services which a mobile subscriber is authorized to use along with the current subscriber location number corresponding to the address of the VLR 40 currently serving the mobile subscriber.

may be performed using any suitable electronic circuitry including DSP, AGIC, suitably programmed main processor, etc.

The traffic load in each base station's cell, sector, or location area is monitored by the BSC 42. However, this operation or function may be performed by other entities such as the MSC 38, each bases station, or other radio network control entity. The BSC 42 includes a traffic load detector 50 which, in this simplified example, monitors the traffic load in area X serviced by a base station 44. The BSC 42 performs similar tasks for each such area for each base station under its control. Traffic load detector 50 includes a comparator 52 and a busy full rate traffic channel (TCH) counter 54. Counter 54 is incremented and decremented to track a current total number of busy traffic channels for that call area "X". A traffic channel is considered busy if it is unavailable to support a full rate call, i.e., the channel is partly or completely allocated for circuit-switched or packet-switched traffic. The output of counter 54 is input to comparator 52 along with a threshold value (T) which may correspond to a certain number of traffic channels set by the mobile network operator. When the output of the counter exceeds the threshold, the comparator generates a traffic load signal which may be used to set a high load flag in controller 56 for cell area X. Preferably, the threshold value (T) incorporates hysteresis to minimize undesired channel rate switching. Thus, controller 56 receives channel requests from various base stations 44 and issues channel assignments for various mobile communications to the base stations. Controller 56 accesses a memory 58 to store a list of dual rate capable mobile stations currently assigned to a full rate traffic channel. In executing various channel assignments and channel drops, controller 56 increments and decrements, respectively, the busy full rate TCH counter 54 for each base station area.

Each base station 44, such as the base station shown for cell area X, includes numerous transceivers used to establish and maintain various channels over the radio

traffic channels (block 100) using the output from the busy full rate counter 54, the threshold input, and the comparator 52 in the traffic load detector 50. A decision is made in block 102 whether the current traffic load exceeds the threshold (which preferably incorporates a hysteresis value). If not, control loops back to block 100 to monitor the traffic load with no change of channel rate being necessary at this time.

If the traffic load in this cell area exceeds the threshold, the BSC controller 56 generates a list 58 of dual rate mobile stations in this cell area X that are currently assigned to a full rate traffic channel that are permitted to use a half rate traffic channel if necessary (block 106). A decision is made in block 108 by controller 56 whether there are any dual rate mobile stations included in the list. If not, control returns back to block 100 to repeat the above procedures.

However, if there are dual rate mobile stations currently assigned to a full rate traffic channel entered on the list, another decision is made in block 110 whether any traffic channel associated with the base station for area X has one half rate connection idle. As described above in conjunction with Fig. 3, a traffic channel can support two half rate traffic channel connections. It is more efficient to fully occupy that traffic channel with two half rate calls. A handover of the current call on the full rate traffic channel for the dual rate mobile station at the top of the list is handed over to the remaining idle half rate connection (block 112). The handover frees up a full rate traffic channel for other call requests some of which may require a full rate traffic channel during this high traffic demand period. Alternatively, the freed up full rate channel may be used to support two new half rate call connections.

The BSC controller 56 generates the necessary handover commands for the base station controller 74 and mobile station controller 92. When the mobile station 46 initially sends a "channel request" message to its serving base station, the base station includes the channel request message with a "channel required" message sent to the

beneath the threshold, the list is cleared in block 22, and the process repeated starting at block 100.

If the traffic load exceeds the threshold in decision block 102, the BSC controller 56 also attempts to increase capacity by assigning half rate traffic channels where permitted/possible for new call requests, see flags A in Fig. 5A, and described in the flowchart illustrated in Fig. 5B. For a high traffic load condition, each new channel request is received (block 130), and the rate capability of the mobile station associated with the channel request is determined (block 132) based on the indication of what kinds of channels the mobile station can handle contained in the channel request message. If a full rate traffic channel is required, (for whatever reason), the channel setup is continued to assign a full rate traffic channel assuming that one is available. However, if a full rate traffic channel is not required for the current call request, a half rate traffic channel is assigned (block 136) and control returns to block 100 in Fig. 5. When the traffic load is detected to have decreased sufficiently, an optional procedure is to permit ongoing half rate calls to be selectively handed over to available full rate channels.

Consider the following simple example. Assume that the base station 44 has a total of four transceivers where each transceiver includes eight time slot channels. Accordingly, the base station includes a total of thirty-two time slots of which three are used for control channel signaling leaving twenty-nine time slots for traffic channels. Again, all base station transceivers are assumed to be capable of carrying full rate and half rate channels. Half of the mobile stations are assumed to be capable of dual rate communications with the other half being capable of full rate communication only. The traffic load threshold is set to seventy-five percent with a hysteresis of five percent. Translated to a number of traffic channels for this example, the threshold is twenty-two busy traffic channels with a hysteresis of one traffic channel. Thus, a high load flag is

four additional traffic channels are made available to service other calls at a relatively minimal cost of performing for intra-cell handoffs. Surges in traffic demands are efficiently met in dynamic fashion without additional base station transceivers.

While the present invention has been described with respect to particular embodiments, those skilled in the art will recognize that the present invention is not limited to the specific embodiments described and illustrated herein. Different formats, embodiments, and adaptations besides those shown and described, as well as many variations, modifications, and equivalent arrangements may also be used to implement the invention. Therefore, while the present invention has been described in relation to its preferred embodiments, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is merely for the purposes of providing a full and enabling disclosure of the invention. Accordingly, it is intended that the invention be limited only by the spirit and scope of the claims appended hereto.

7. The method in claim 1, wherein the changing step includes:

performing an intra-cell handover of the communication from the first rate traffic channel to the second rate traffic channel.

8. The method in claim 1, wherein the second rate is corresponds to a bit rate of 6.5 kbits/s and the first rate corresponds to a bit rate of 13 kbits/s.

9. The method in claim 1, wherein the second rate communication occupies one half of the capacity occupied by the first rate communication.

10. The method in claim 1, further comprising:

assigning the second rate communication to a traffic channel currently supporting another second rate communication.

11. The method in claim 1, further comprising:

compiling a list of dual rate mobile stations having the capability to communicate using either the first rate and the second higher rate.

12. The method in claim 11, further comprising:

employing hysteresis in the determining step.

13. A method for increasing capacity in a cellular communications system where mobile stations in cell areas communicate with corresponding base stations over traffic channels, comprising the steps of:

in response to a request to establish a traffic channel for a communication with a mobile station in a cell area, determining a traffic channel rate capability of the mobile station;

determining a cell area traffic load; and

if the cell area traffic load exceeds a threshold and if the mobile station has the capability to communicate using either a first higher rate and a second lower rate,

controller coordinating the setup of a first rate traffic channel for a communication with a mobile station being served by a base station, comprising:

a memory storing traffic channel rate capabilities of plural mobile stations served by the base station, and

data processing circuitry, connected to the memory, programmed to perform the following tasks:

determining a traffic load at the cell corresponding to the base station, and

if the traffic load at the cell exceeds a threshold, reassigning the communication to a second lower rate traffic channel.

22. The controller in claim 21, wherein the mobile station has the capability to communicate over first and second rate traffic channels.

23. The controller in claim 21, wherein the data processing circuitry executes an intra-cell handover of the communication from the first rate traffic channel to the second rate traffic channel.

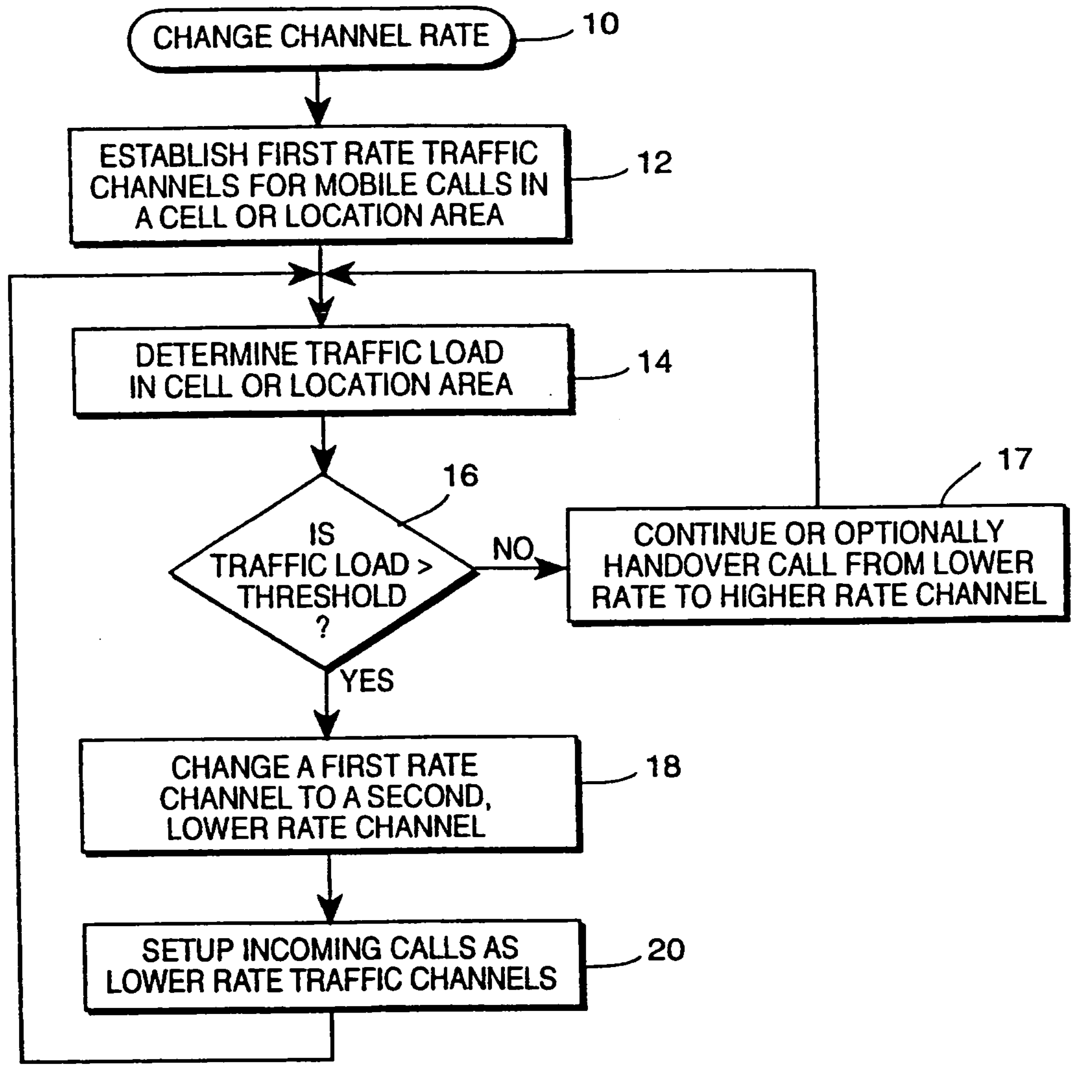
24. The controller in claim 21, wherein the second rate is corresponds to a bit rate of 6.5 kbits/s and the first rate corresponds to a bit rate of 13 kbits/s.

25. The controller in claim 21, wherein the second rate communication occupies one half of the capacity occupied by the first rate communication.

26. The controller in claim 21, wherein the data processing circuitry assigns the second rate communication to a traffic channel currently supporting another second rate communication.

27. The controller in claim 21, wherein the memory stores a list of dual rate mobile stations having the capability to communicate using either the first rate and the second higher rate.

Fig. 1


CHANGE CHANNEL RATE
10
ESTABLISH FIRST RATE TRAFFIC CHANNELS FOR MOBILE CALLS IN A CELL OR LOCATION AREA
12
DETERMINE TRAFFIC LOAD IN CELL OR LOCATION AREA
14
IS TRAFFIC LOAD > THRESHOLD ?
16
NO
CONTINUE OR OPTIONALLY HANDOVER CALL FROM LOWER RATE TO HIGHER RATE CHANNEL
17
YES
CHANGE A FIRST RATE CHANNEL TO A SECOND, LOWER RATE CHANNEL
18
SETUP INCOMING CALLS AS LOWER RATE TRAFFIC CHANNELS
20

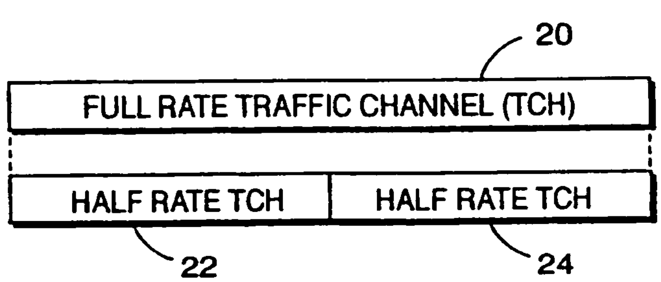

20
FULL RATE TRAFFIC CHANNEL (TCH)
HALF RATE TCH
HALF RATE TCH
22
24

Fig. 3

Fig. 4

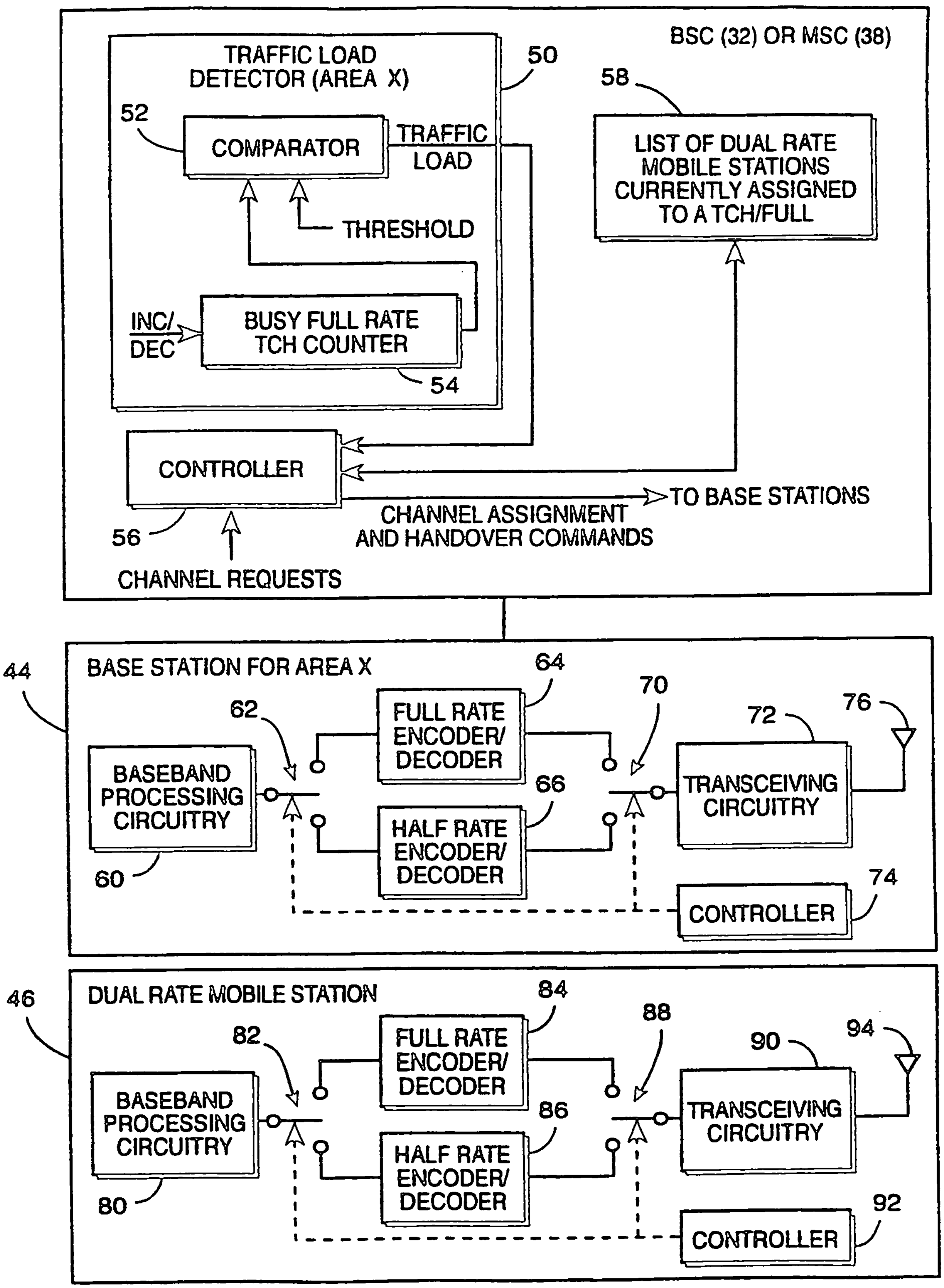
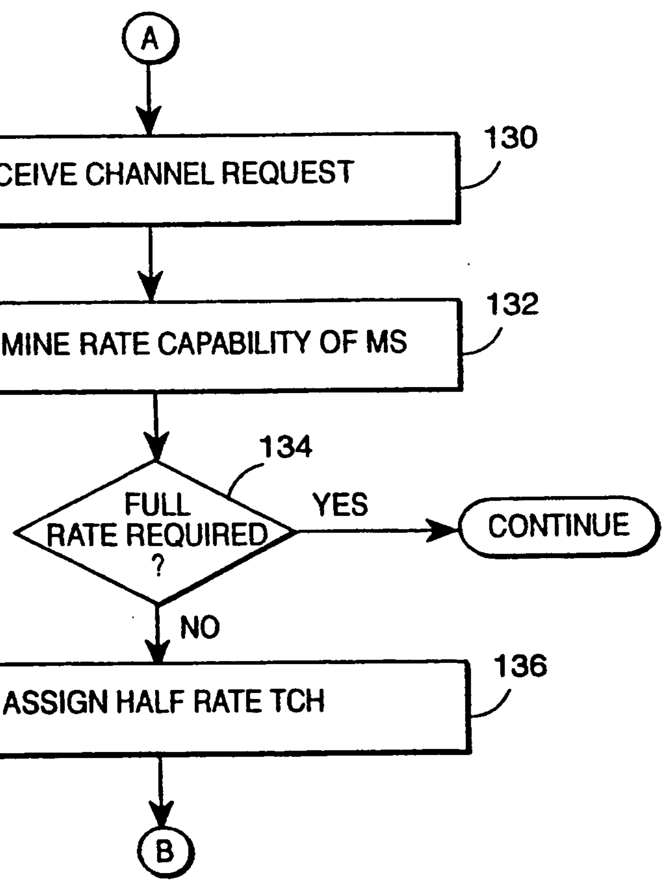

BSC (32) OR MSC (38)
TRAFFIC LOAD DETECTOR (AREA X)
50
52
COMPARATOR
TRAFFIC LOAD
THRESHOLD
INC/ DEC
BUSY FULL RATE TCH COUNTER
54
58
LIST OF DUAL RATE MOBILE STATIONS CURRENTLY ASSIGNED TO A TCH/FULL
CONTROLLER
TO BASE STATIONS
CHANNEL ASSIGNMENT AND HANDOVER COMMANDS
56
CHANNEL REQUESTS
44
BASE STATION FOR AREA X
64
62
FULL RATE ENCODER/ DECODER
70
72
76
BASEBAND PROCESSING CIRCUITRY
66
TRANSCEIVING CIRCUITRY
HALF RATE ENCODER/ DECODER
60
74
CONTROLLER
46
DUAL RATE MOBILE STATION
84
82
FULL RATE ENCODER/ DECODER
88
90
94
BASEBAND PROCESSING CIRCUITRY
86
TRANSCEIVING CIRCUITRY
HALF RATE ENCODER/ DECODER
80
92
CONTROLLER

Fig. 5B


A
RECEIVE CHANNEL REQUEST
130
DETERMINE RATE CAPABILITY OF MS
132
134
FULL
RATE REQUIRED
?
YES
CONTINUE
NO
ASSIGN HALF RATE TCH
136
B